

Final Report

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Investigator: A.D. Poularikas
Electrical and Computer Engineering Department,
The University of Alabama in Huntsville, AL 35899

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Purpose:

The purpose of this investigation is to develop high resolution infrared radiative transfer models and inversion techniques for remote sensing of the stratosphere and mesosphere from space platforms.

Background:

Observation of infrared spectra of atmospheres provides a powerful remote sensing means for studies of chemical and physical processes in atmospheres. The Earth's atmospheric molecular constituents absorb and emit infrared radiation by vibrational and rotational transitions, and the observed spectra exhibit characteristic spectral features in this region of the electromagnetic spectrum. Absorption or thermal emission spectra of the Earth's limb may be obtained with space-borne high resolution infrared spectrometers in the $10\text{-}5000\text{ cm}^{-1}$ ($2\text{-}1000\mu\text{m}$) spectral region. A detailed analysis of the observed spectra leads to a wealth of information about the atmospheric thermal structure, composition, and the physical and chemical processes. The analytical techniques involve the development of radiative transfer models for calculation of the observable radiances and transmittances for realistic atmospheric conditions and observational geometries, and the development of inversion methods for retrieval of atmospheric parameters from the observations. The investigation being carried out under this task deals with the development of analytical techniques for interpretation of infrared observations in the $10\text{-}5000\text{ cm}^{-1}$ region under a variety of atmospheric and observational conditions.

Approach:

The Principal Investigator and his collaborators have been involved for many years in the development of radiative transfer models and inversion techniques for analysis of high resolution

stratospheric limb thermal emission and absorption measurements. A capability for analysis and interpretation of infrared emission and absorption measurements has been developed at the Marshall Space Flight Center by modification of the existing programs for applications to the currently operating or planned missions. The analytical techniques have been modified by removing several deficiencies in the calculations, and by incorporating some important atmospheric processes not considered adequately in the existing models. Among these are: development of models for continuum absorption calculations for water vapor in particular in the far infrared spectral region of 60-2000 cm^{-1} ; development of pressure induced absorption models for O_2 and N_2 and their comparison with available observations; algorithms for reference pressure calculations for limb viewing observations; and a preliminary study of the non-LTE effects in the upper stratosphere and the mesosphere for infrared active gases. These improved versions of the programs provide a capability for more accurate analysis of infrared observations with considerably reduced uncertainties in the retrieved parameters. These techniques are being tested on some available observations.

Accomplishments:

The research work carried out deals with the development of analytical techniques, and requires experienced computer programmer and graduate student support. During the course of this investigation, the work progress was interrupted twice because of the unexpected departure of the experienced student/programmers working on the program (Charles Noun and S. Hamidi from UAH). The difficulty encountered in finding suitable personnel, and the time required in the training process, has lead to considerable delays in completing the tasks on schedule. Since March 1992, two UAH graduate students (Kim and Sahawneh) have been working on the programs, and after some initial period of training, are making satisfactory progress.

The tasks completed in FY 92 are the following: The newly developed techniques and programs were employed for analysis of balloon-borne far infrared data by the group headed by Dr. Wesley Traub at Harvard-Smithsonian Center for Astrophysics. The empirical continuum absorption model for water vapor in the far infrared spectral region, and the pressure induced N₂ absorption model were found to provide satisfactory results in retrieval of the mixing ratios of a number of stratospheric trace constituents from balloon-borne far infrared observations. A research paper based on this work was published in abstract form and presented at the AGU annual Spring Meeting in April 1992, and a comprehensive paper has been accepted for publication in the Journal of Geophysical Research. Two research proposals based on applications and extensions of this work to current and future mission observations have been submitted.

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